NASA/CP—2000–210428

National Forum on
The Future Development of Space

Compiled by
D. Dooling
D2 Associates, Huntsville, Alabama

Edited by
D.V. Smitherman, Jr.
Marshall Space Flight Center, Huntsville, Alabama

Summary of a Conference held March 16, 1999,
by the National Aeronautics and Space Administration
and the U.S. Chamber of Commerce

August 2000

The NASA STI Program Office…in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA's counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.

- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.

- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.

- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or cosponsored by NASA.

- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and mission, often concerned with subjects having substantial public interest.

- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results…even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at ***http://www.sti.nasa.gov***

- E-mail your question via the Internet to help@sti.nasa.gov

- Fax your question to the NASA Access Help Desk at (301) 621–0134

- Telephone the NASA Access Help Desk at (301) 621–0390

- Write to:
  NASA Access Help Desk
  NASA Center for AeroSpace Information
  7121 Standard Drive
  Hanover, MD 21076–1320

NASA/CP—2000–210428

National Forum on
The Future Development of Space

Compiled by
D. Dooling
D2 Associates, Huntsville, Alabama

Edited by
D.V. Smitherman, Jr.
Marshall Space Flight Center, Huntsville, Alabama

Summary of a Conference held March 16, 1999,
by the National Aeronautics and Space Administration
and the U.S. Chamber of Commerce

National Aeronautics and
Space Administration

Marshall Space Flight Center • MSFC, Alabama 35812

August 2000

Acknowledgments

Sponsors: This forum was co-sponsored by the National Aeronautics and Space Administration (NASA) and the U.S. Chamber of Commerce. Corporate sponsors were The Boeing Company, and VentureStar, a Lockheed Martin Company. Cooperating organizations were the Aerospace Industries Association, Aerospace States Association, American Aeronautical Society, American Institute of Aeronautics and Astronautics, International Space Business Council, National Space Society, National Technology Transfer Center, ProSpace, and the Space Frontier Foundation.

Illustrations: Boeing, p.2; Iridium, p. 4; Lockheed Martin Co., Boeing, p. 6: Space Imaging and Space Adventures, p. 8; Lockheed Martin, p. 21; Spacehab, p. 23; and Space Adventures, p. 24. Cover art and all other illustrations are from NASA. Charts by Dave Dooling.

Available from:

NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076–1320
(301) 621–0390

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487–4650

PREFACE

The exploration of space has been a successful national priority for decades. We've landed on the Moon, built the Shuttle, and are building the *International Space Station*. But we've only just begun to develop the real commercial potential of space. How large is this potential for the broader business community? What are the greatest opportunities? What are the technology, policy, and business strategies required to harvest real business value from space? How can we as policymakers, investors, researchers, and business leaders ensure that the commercial development of space advances at a pace and breadth that brings most benefit to the national economy? To address these related questions, NASA and the U.S. Chamber of Commerce co-sponsored a 1-day National Forum on the Future Development of Space, held March 16, 1999, in Washington, DC, at the U.S. Chamber Headquarters. This report documents the key findings from this forum.

During the conference, the participants moved beyond the traditional sectors of transportation and communications, and explored both mid-term and longer term business prospects of space development, including public space travel, new space industries, energy generation, remote sensing, zero gravity manufacturing, space business parks, etc. Future sectors were explored such as tourism, real estate, space mining, and other opportunities. This realistic assessment of the commercial potential of various sectors was followed by an exploration of what needs to be done from a management, financial, technical, legal, regulatory, and legislative perspective to allow the business of space to emerge and thrive.

Throughout the day the participants were invited to electronically register their views regarding the key questions raised. These data were compiled and are illustrated in the figures included in this report. The collective views are serving as the basis for initiatives well beyond the forum.

This report documents the highlights of the event and captures the exciting, informative, and rewarding exploration of the next phase of the national development of space—realizing its true commercial promise.

Willard A. Workman, Vice President,
International
U.S. Chamber of Commerce

Editor's note: Adapted from Mr. Workman's invitation letter to the forum participants.

Foreword...

What we are trying to do today is to focus on space from the business perspective. When you think about it, outer space has always captivated the imagination of our fellow citizens and of the citizens of the world. From the ancient gods and goddesses, for whom the planets were named, to modern television, artists, poets, writers, and scientists; all have contemplated in their own way and have tried to explain the mystery of the cosmos. Today, that becomes a little more interesting because advanced scientific knowledge has removed some of this romance from outer space, but clearly not all of it.

The idea of unexplored regions, new adventures, and even undiscovered treasures engages our 20th-century imaginations as surely as the uncharted waters of the Atlantic Ocean engaged the imagination and vision of the 15th-century explorers. Space still captures our imagination; so we are here today to discuss one facet of this enormous topic—business and space development. As the nation's largest business federation, the Chamber has always supported efforts to help American business to adapt and expand in foreign markets, cyberspace, and now outer space.

The Chamber's sponsorship of today's forum signals our belief that, for many American firms, dreams of development in space are fast becoming a reality. We are also on the verge of meeting technical, financial, and regulatory challenges that will open space to mainstream business. For years, it was really a military or NASA issue. The rapid and impressive gains of satellite communications and the industry that uses them are just one example.

Other sectors are lining up to enter this new territory as well, in a big way, from the traditional launch and service sector to a whole new set of industries spawned by satellite-based imaging. In short, growth estimates of space-related industry reach into the hundreds of billions of dollars. While the pace of this development will vary with the sector, space exploration may fuel major business growth in the first decades of the new millennium. Whether or not we can capitalize on such potential really remains an open question. NASA has already made an excellent start, focusing less on contracting and more on collaborating with business.

However, I think we all agree that there is a need for more consistent space development policy. We need sustained effort to bring small- and medium-sized entrepreneurs to the table. We need to think hard about how to establish innovative approaches to the relationship between the public and the private sectors in this area. We should not forget that space is already a site for international competition as well as cooperation. As we explore the commercial reality of space, we need to explore new ways of financing, motivating, and involving U.S. firms so that they will be prepared to compete.

Now, what are the best ways to harvest the benefits of space development? How can we move forward more rapidly? Today we are going to learn what the best thinkers in this country and the best scientists in our nation envision. The forum has been designed to be very interactive with plenty of opportunities for everyone to help build a consensus or to challenge prevailing thought. By the end of the day, we hope that everyone will have a better understanding of the challenges and opportunities that lie before us and a better idea of what it will take to move forward. I hope everyone goes home with one idea—that they think coming here was very worthwhile because they got it and they are going to go and do something with it. Now, I would like to leave you with one thought.

It was 70 years ago today that the first liquid fuel rocket was successfully launched by Professor Robert Goddard in Auburn, Mass. Now, that rocket traveled 184 feet in 2.5 seconds. That was a watershed event, one of many fundamental advances in technology that we enjoy today. Who would have imagined then what we know to be reality today?

Today's forum can help us launch new visions and new solutions that will take us through the next 70 years. Who would have imagined then and what can you imagine today that we will be doing 70 years from now?

Thomas Donahue, President and CEO
U.S. Chamber of Commerce

... and Fast Forward

During the National Forum, 96 percent of the participants indicated that they would join a broad-based space development council that would help develop new commercial initiatives and provide private sector input to the policy and regulatory environment affecting space commercialization.

In response, in early 2000 the Chamber formed the Space Enterprise Council. This is an opportunity for the U.S. private sector to take a leading role in developing and advocating policies and programs that most effectively encourage the U.S. commercial development of space. Its objectives are *advocacy* to define and convey to policymakers a national business agenda on effective policies and strategies to advance the commercial development of space, *services* to provide business development services and initiatives and to act as a business facilitator, bringing together companies, including those currently not using space as a research or business venue, and *education* to broaden awareness and participation of U.S. firms in space development via conferences, road shows, print and web materials, etc.

For information, contact: Dawn Sienicki, Director, Space Enterprise Council, U.S. Chamber of Commerce, 1615 H Street, NW, Washington, DC 20062–2000 (202–463–5479), www.uschamber.com/intl/space

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Illustrations

LIST OF CHARTS

Charts (keyed to audience survey)

LIST OF ACRONYMS

ACTS	Advanced Communications Technology Satellite
AERCam	autonomous extravehicular robotic camera
AURA	Association of Universities of Research in Astronomy
DoD	Department of Defense
EELV	evolved expendable launch vehicle
ELV	expendable launch vehicle
EVA	extra-vehicular activity
GEO	geostationary Earth orbit
GNP	Gross National Product
GOCO	government-owned, contractor-operated
ISS	*International Space Station*
JPL	Jet Propulsion Laboratory
LEO	low-Earth orbit
NASA	National Aeronautics and Space Administration
NGO	nongovernmental organizations
NIH	National Institute of Health
RLV	reusable launch vehicle
SSTO	single stage to orbit
STSI	Space Telescope Science Institute
TOS	transfer orbit stage

AGENDA AND PARTICIPANTS

Welcome

Thomas J. Donohue, President and Chief Executive Officer, U.S. Chamber of Commerce

The National Importance of Space Development

Daniel S. Goldin, Administrator, National Aeronautics and Space Administration

Senator John B. Breaux (D-LA), Senate Commerce, Science, and Transportation Committee

Durrell Hillis, Senior Vice President and General Manager, Systems Solutions Group, Motorola, Inc.

Panel 1: What are the Potential Commercial Opportunities in Space?

Moderator: *Lori B.Garver*, Associate Administrator, Office of Policy and Plans, NASA

Transportation and Infrastructure:

Joseph H. Rothenberg, Associate Administrator, Office of Space Flight, NASA

Richard Stephens, Vice President and General Manager, Reusable Space Systems, The Boeing Company

Jerry Rising, President, VentureStar

Microgravity: *David A. Rossi*, President, SPACEHAB, Inc.

Remote Sensing: *Mark Brender*, Director, Washington Operations Space Imaging/EOSAT, LLC

Horizon Market Opportunities: *Gloria Bohan*, President and Chief Executive Officer, Omega World Travel

Lunch, hosted by The Boeing Company

Speaker: *Representative Alan B. Mollohan* (D-WV), Ranking Minority Member, Subcommittee on VA–HUD and Independent Agencies, House Committee on Appropriations (not included in summary)

Panel 2: What are the Challenges to Commercial Space Development?

Moderator

Jerry Grey, Director, Aerospace and Science Policy, American Institute of Aeronautics and Astronautics

Policy: *Robert Walker*, President, The Wexler Group (former Chairman, House Committee on Science)

Technology: *Joel Porter*, Vice President for Advanced Programs, Lockheed Martin Astronautics

Finance/Insurance: *Rick Hauck*, President and Chief Executive Officer, AXA Space (former astronaut)

Legal/Space Law: *James Dunstan*, Attorney and Partner, Haley, Bader, Potts

Public/Private Roles: *Robert Werb*, Partner, Orbital Properties, LLC

Panel 3: What Must be Done to Meet the Challenges Facing Space Development?

Moderator: *Warren Corbett*, Managing Editor, United Press International, Broadcast Division

Panelists

Buzz Aldrin, Chairman and Chief Executive Officer, Starcraft Industries, Inc.; Apollo 11 astronaut

Shubber Ali, Manager, Space and High Technology Practice, KPMG Peat Marwick

R.V. Davis, President, R.V. Davis & Associates (former Deputy Undersecretary of Defense for Space)

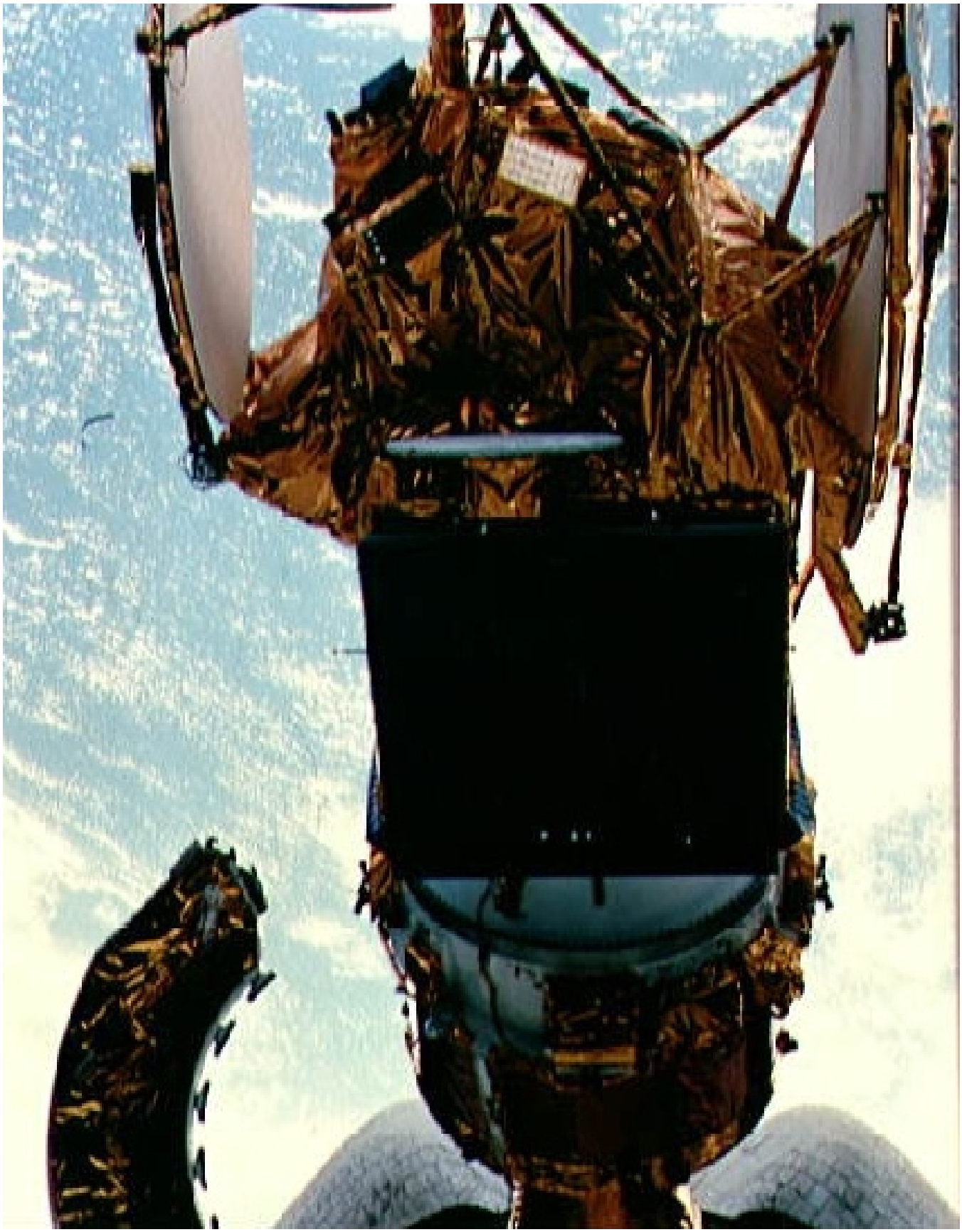
Charles Lauer, Vice President, Business Development, Pioneer Rocketplane

Alan Ladwig, Senior Advisor to the Administrator, NASA

Ed Tuck, Partner, Kinship Partners II

Rick Tumlinson, Executive Director, Foundation for the International Non-Governmental Development of Space and President, Space Frontier Foundation

Closing Remarks



CONFERENCE PUBLICATION

NATIONAL FORUM ON THE FUTURE DEVELOPMENT OF SPACE

THE NATIONAL IMPORTANCE OF SPACE DEVELOPMENT

Daniel S. Goldin, Administrator, National Aeronautics and Space Administration

Leaving home behind in quest of the planets and letting corporate America tend to business in Earth orbit was the theme outlined by NASA Administrator Dan Goldin in his opening speech.

"For the last 40 years, NASA has been mostly in low-Earth orbit [(LEO)] and even today 90 percent of our budget is focused on low-Earth orbit," he said. "It is the hope and vision of NASA, in the next decade to decade and half, that we leave low-Earth orbit and hand it over to the American commercial sector. We don't want to operate there, we don't want to do any more remote sensing of Earth; we want to do remote sensing of planets and stars. We don't want to put people into low-Earth orbit; we want to put people on planets and put robots around stars."

Goldin outlined how NASA technology transfer has benefited life on Earth, including computational work on a heart-assist pump, remote sensing assistance to farmers in the Mississippi Delta and pioneering work on telemedicine through communications satellites. But the agency is also committed to working with the commercial sector and helping space become "a primary engine in the U.S. economy for the next century… Government will not make it happen; we will be an enabler. We will be a catalyst, but it is the commercial sector that is crucial."

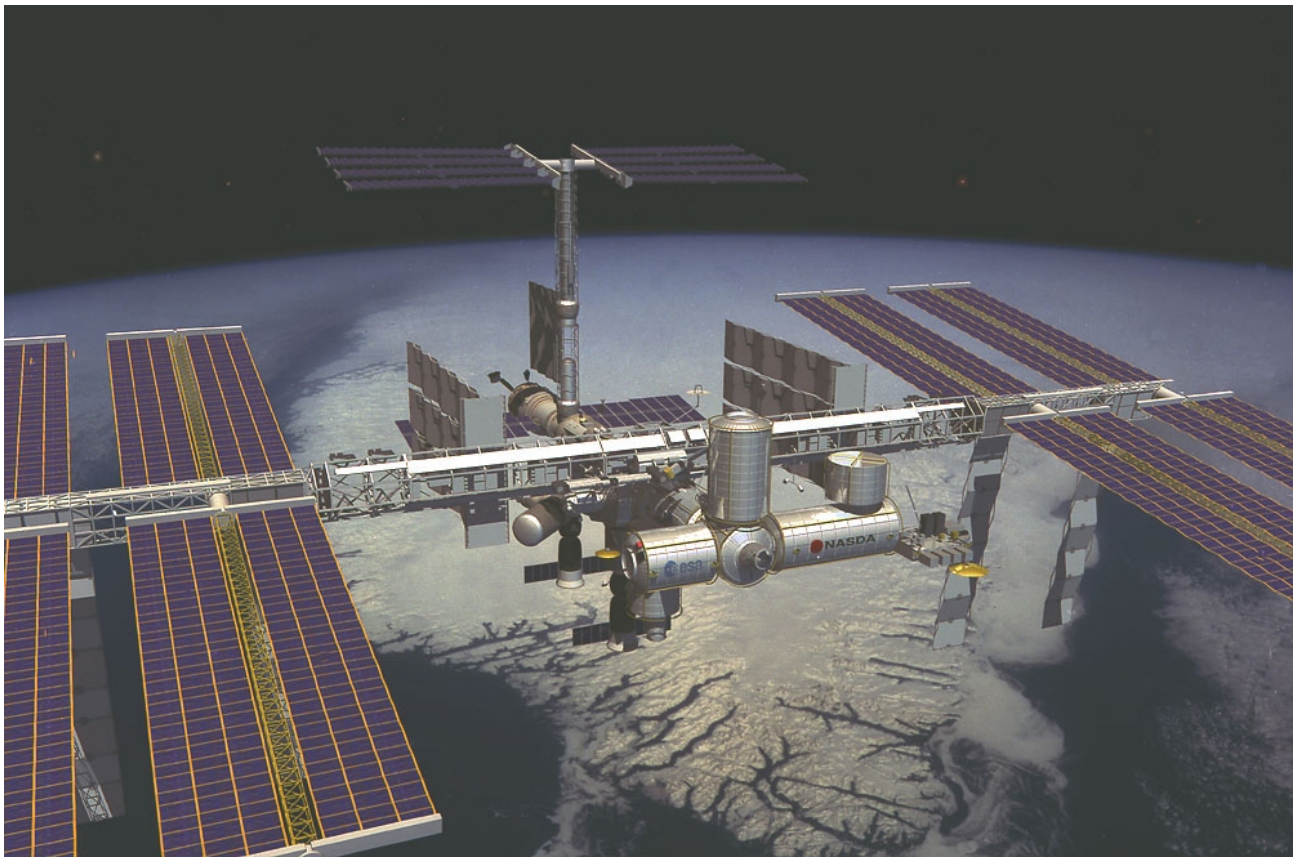
He noted that Space Vest, a venture capital company, predicts that space activities generate about $80 billion in global annual business revenues and will grow to an estimated $200 billion within 10 years. "This will occur if new markets can be created and new partnerships formed with the government and the R&D community and mostly the entrepreneur private sector," Goldin cautioned. He cited the work of Iridium and Teledesic in taking technologies that NASA had developed since the 1970's and turning them into a communications industry using small, mass-produced satellites.

"They have transformed the industry with the emphasis on volume production and rapid deployment of satellites and they went global," he said. "And they did it without any money from the government. That is what I call true commercial development of space." He also noted that he is often approached by companies that have commercial ventures and want NASA to start them off with the first hundred million dollars and to be the key customer. "That is not commercial," Goldin said. "We throw them out of my office."

Sounding a theme that would be repeated many times at the forum, Goldin noted that the high cost of getting into orbit can be several times the cost of actually building the satellite. He pointed out that there have been no breakthroughs in the last 25 to 30 years in space transportation and that the United States has gone from holding 80 percent of the launch business to about 30 or 40 percent, even though it builds 80 percent of the satellites that are launched. This was one of the drivers that led to the current X-vehicles program to drive down the cost of launches to 10 percent of its current level in 10 years, and to 1 percent in 20 years. An important boost will come from the commercial loan guarantee bill—modeled after shipbuilding loan programs—introduced by Senator John Breaux of Louisiana.

These should lead to vehicles that NASA neither owns nor operates, Goldin continued. Already, NASA is privatizing the operation of the Space Shuttle by contracting with United Space Alliance to handle all operations and issuing a Consolidated Space Operations Contract to handle all non-Shuttle space operations under a single contract. These actions "are expected to result in approximately $1.4 billion savings to the American taxpayer and help start up a whole new private sector activity in America."

The STS–51 mission embodied two aspects of space commercialization. The Advanced Communications Technology Satellite (ACTS) led to development of low-altitude communications satellites, led by Iridium. The Transfer Orbit Stage (TOS) was a result of favorable tax credits that made possible investments leading to formation of a major space company.



The *International Space Station* as it will appear at completion.

Looking farther out, Goldin anticipates that operation of the *International Space Station (ISS)*, now under construction, will be turned over to private enterprise. In the near term, 30 percent of research time on the *ISS* is to be allocated to U.S. commercial ventures.

"This means that for the first time business will be able to take its ideas, its questions, and innovations into space in a real hands-on laboratory environment—not for a few days at a time but for weeks, months, and even years," Goldin continued. "The private sector will determine how to utilize this set-aside. In fact we intend to have a competition to see if there is a company willing to take on utilization of the research on the Space Station and manage this research park in space." Eventually other orbital platforms will be developed under commercial funding and "may become the true business park in space."

The other major area already starting significant commercial growth is remote sensing of Earth resources from orbit. NASA started the field with the Landsat series of satellites in 1972; Landsat 7 was launched in April 1999, and another 30 remote sensing satellites are planned over the next 5 years.

"This is not a theoretical business," Goldin said. "This value-added business is real. In 1992, this industry was already growing $750 million in revenues. Just 6 years later, those revenues have grown to $2 billion a year." Revenues are predicted to reach $10 billion by 2010, and U.S. companies are planning to invest $2 billion in the next few years in privately owned and launched remote sensing systems.

Looking farther out, Goldin predicted that space travel and the utilization of space resources—notably water ice on comets or asteroids—will become growth industries. "Public space travel is an exciting idea that will appeal to tens of thousands and hopefully hundreds of thousands of people who would like to go into space, but the price and safety have to be right," he said.

Goldin said that while the United States is deeply committed to international cooperation in space, it will also encourage competition because too much cooperation leads to mediocrity. "We will cooperate on science, we will cooperate on long-term technology, but we will compete like hell on access to space and things crucial to the security of this nation. Remember, 'You ain't seen nothing yet.'"

Senator John Breaux (D-LA), Member of the Senate Commerce, Science, and Transportation Committee; Chief deputy whip and senior member of the Finance Committee

One of the great puzzles of the late 1990's is "why we are not in the absolute leadership role in all aspects of space, both in the commercial utilization of space as well as the other programs" even while the nation was riding one of the biggest economic booms in history, wondered Senator John Breaux (D-LA), a member of the Senate Committee on Commerce, Transportation, and Science. Coming from Louisiana, Breaux is concerned about two high-tech industries: shipbuilding and space transportation (Space Shuttle external tanks are built in New Orleans).

"The question for most members of Congress is, 'Why don't we just use our own rockets? Why is there a problem? Why are we not first in the launch vehicle aspect of this very important aspect of outer space and the commercial utilization of outer space?'" he asked. The answer, already known in the launch business and other parts of the aerospace industry, is that the United States often competes against nations that directly support industries and do not have market-based economies. "It is very difficult, if not impossible, for us to compete in these areas," he noted.

The problem has deeply affected the U.S. shipbuilding industry where buyers look for the best price and quality regardless of the source. "When we compete against countries who are not concerned about making a profit, we generally come out second best in all of these areas," Breaux continued. The United States has had some success in eliminating shipbuilding subsidies in other nations, but "this is one area as far as space exploration and space launch vehicles is concerned where there is no governing international agreement that prevents countries from heavily subsidizing their launch vehicles." Substantial government ownership in or subsidies of launch industries in other nations keep U.S. companies from competing on a level playing field.

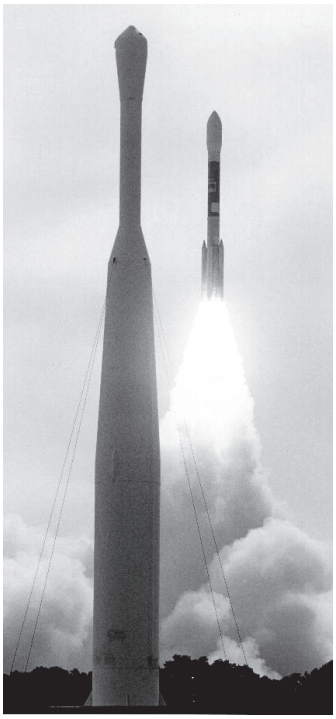
"So what can you do about it?" he asked. "Do you pass a law saying you can't use foreign rockets? No, we are not going to do that."

A solution that Breaux is offering is S649, a Senate bill to provide guaranteed loans for the expendable and reusable launch industries that parallels an established loan program for the shipbuilding industry.

The Commercial Space Transportation Cost Reduction Act of 1999 has as its primary goal to reduce the cost of launching satellites either through expendable launch vehicles (ELV's) or reusable launch vehicles (RLV's), and to make U.S. industries more competitive than having to compete against countries where price and profit are of no concern. The bill creates a loan program similar to the Title 11 Shipyard Guarantee Program that reduces private sector risk by letting the U.S. Government guarantee a portion of a loan so that a company can get a loan in the commercial market at a favorable rate. NASA will not be involved beyond offering technical advice. The program will be housed in the Department of Transportation (where the Title 11 program is managed) under the Office of Commercial Space Transportation.

The program also will be "technology neutral" so the government does not pick winners and losers. RLV's, ELV's, and even Space Shuttle upgrades would be eligible, "as long as they demonstrate a potential for significant reduction in the launch cost and have a viable program to be presented that has a good chance of being successful." Only the evolved ELV (EELV) program would be excluded, since it is funded by the U.S. Air Force.

The initial funds available to the loan program would be $500 million which, Breaux maintained, could be leveraged to $5 billion in financing. The government would not actually make loans, only serve as a guarantor so the private sector could more easily acquire private funding. Eligible companies would have to have some experience in the field. Loans would be for up to 80 percent of the project's costs and would be repaid over a period of 12 years. From 10 to 20 percent would be set aside for small businesses. Beneficiaries would be obligated to ensure the lowest prices to the U.S. Government, and the government would have a claim on vehicles in time of an emergency. Again, these features parallel the shipbuilding loan program.



Development of the Delta II (rising) from the Thor-Able (foreground) was government funded.

"The government role is not to pick winners or losers but to try and create opportunities for everyone in a fashion that relies on the private marketplace," Breaux added.

Durrell Hillis, Senior Vice President and General Manager of the Motorola Systems Solution Group

Just as the loan guarantee program is a break from conventional practice, the Iridium communications satellites produced by Motorola also were the product of unconventional methods. Even the basic concept is different, using a constellation of LEO communications satellites that hand off calls to each other as they pass over an area where an individual is making a phone call. In the end, Iridium built and launched 66 satellites in the space of 3 years.

"You couldn't do what has been done by following previous practices," said Durrell Hillis, Senior Vice President and General Manager of the Motorola Systems Solution Group. Where conventional practices have served well for many past programs, for something like Iridium "you really have to take a clean sheet of paper … and create a system and a process and a methodology that is appropriate for what you are trying to accomplish." Rather than developing a stack of specifications, as is the case in a government project, "the Iridium program specification was based upon two very, very simple principles." Those were: What kind of orbit and how many satellites are needed to cover the globe from low altitude and what is the power flux density needed so a signal can be received and sent from inside an automobile? The latter was determined by putting several cars on a carousel and measuring signals at various angles.

"We literally designed and built a system from a handset up, based upon some very simple functional requirements," Hillis continued. The system was also designed to be robust with enough satellites to tolerate a few failures in the system. Testing the satellites also took a different form. The first few were subjected to extensive qualification testing, after which the production units were subjected only to thermal testing. At peak production, a satellite was completed every 4.5 days in a relatively small facility.

The other end of the link, the handset used by individuals, was designed to be as compatible as possible with regional cell phone systems, either directly or with small adapters.

Despite the focus on Iridium's radical approach to communications satellites, Hillis claims that "fundamentally, it is a global telecom network that is dominated by software and about two-thirds of the people working on the program in our facilities are telecom and software people and one-third of them have a space legacy."

However, the program was made possible by technologies developed by NASA and adopted by the commercial sector. Motorola's involvement has included manned space communications since the Mercury program and, in the late 1980's, the Advanced Communications Technology Satellite (ACTS).

"The satellite was sometimes called the switchboard in the sky," Hillis explained. "It was a large factor in us believing that we could do something like Iridium, because we had already done the fundamental switching technology. Even though it wasn't the same, it proved to us that kind of concept was viable."

Approaches like Iridium will become widespread, Hillis predicted, because the distance to geostationary orbit imposes a time delay that will limit the use of those satellites in the asynchronous transfer mode that is increasingly used in data transfers.

"What's really coming in the satellite communications world addresses a trillion-dollar market encompassing virtually all forms of communications and information transfer," he said. "Within 5 to 8 years … you have the option of throwing out all the devices in your home that currently connect you to another place, person, or device and replacing them with a single-bandwidth, on-demand access device that will provide you with every information service that you can imagine. Everything from limitless virtual phone lines to laser disc quality, two-way, real-time interactive video, the rapid transfer of huge computer files, in addition to expandable flexible global corporate Internets that can add nodes in a couple of hours to any point on the planet with a potential of providing OC3 or 155-megabit service to any potential location with potential prices, I believe will be for an equivalent of a 64-kilobit virtual circuit."

Iridium satellite and phone.

PANEL 1: WHAT ARE THE POTENTIAL COMMERCIAL OPPORTUNITIES IN SPACE?

Unlike many of the commercial opportunities in the history of humankind, space involves no physical material that can be converted into a new product. Rather, the commercial value of space largely derives—for the present—from two principal features: location and condition. As a location, space provides clear, virtually unobstructed views for instruments looking back at the Earth or deeper into space and for communications relay stations that rise above the horizon.

As a condition, space readily offers a physical state frequently called zero-g or weightlessness, more properly called microgravity. This allows materials to take forms and values that are not possible on the ground under the full effect of Earth's gravity. In addition, other space resources may be tapped, including solar energy for the space solar power technology and lunar resources like oxygen and perhaps subsurface polar ice, etc. Indeed, any kind of extraterrestrial materials returned to Earth would have scientific and high commercial sales value, although none is currently accessible.

Exploiting these possibilities gives rise to another need and opportunity: transportation to and from orbit. To date, it has made admission to space costly and difficult. Lower launch costs and more frequent launches will broaden commercial opportunities.

Transportation and Infrastructure

"We need to make access easy," said Joseph Rothenberg, NASA Associate Administrator for Space Flight. "Today, you have to go through a number of processes to utilize both the Shuttle and Space Station for research. Safety processes, design facility processes, all these things most industrial investors are not that interested in because of the high cost and the time, the risk, and the uncertainty of ability to get to space." The process needs to be more transparent to users, be faster and take advantage of economies of scale. The challenge lies not in just making the Shuttle more user-friendly, but in commercializing the *ISS*. The latter requires simplifying the use of the Station, identifying commercial opportunities (ranging from science and technology to entertainment and advertising), and having returns from the Station pay for its operation.

"Ultimately, if that is successful, and the opportunities are there," Rothenberg added, "I fully believe that at some point NASA will become a user of the Station rather than an owner of the Station."

To that end, NASA plans to start testing markets for the *ISS*, and has a Space Station Commercial Development Plan that identifies several opportunities.

"There is going to have to be some unique value of space that commercial industry sees as a tremendous return or opportunity for a return which will motivate them to invest," he said. "NASA does not know how to do that … . The best ones who know how to do that are venture capitalists, entrepreneurs." Getting the entrepreneurs there will be the responsibility of companies providing transportation. "Companies don't care when they are putting payloads into orbit if they are on an expendable vehicle or reusable vehicle," said Rick Stevens of The Boeing Co. "They want low cost; they want assured access."

The two largest U.S. launch companies are developing similar approaches to improve access to space. The Boeing Co. and Lockheed Martin Co. are developing EELV's for the U.S. Air Force. These also will see wide use as commercial launchers. Boeing also is the prime contractor for the U.S. Space Shuttle, and Lockheed Martin is developing the X–33 demonstrator that will pave the way for the VentureStar RLV. But the path is still being blazed.

"Fundamentally, we are on a journey," Stevens explained. "The ideal is that we end up with a market-driven solution to where we are trying to go in the commercial and space business. The challenges that we all face, though, are the timing for the market, balancing our investment against meeting those market requirements, trying to sort out where technology stands, and how best to apply that technology, and the last is trying to bring those three ingredients together, all at one time, to be able to meet market needs."

An important factor is that the government is becoming "a" customer rather than the only customer, and is moving toward purchasing services rather than operating systems, as is the case with the EELV, in which the Air Force selected both Boeing and Lockheed Martin to develop competing products rather than award a single contract.

The EELV is comprised of two families, the Lockheed Martin Atlas II series (left) and the Boeing Delta IV (right).

Another major change taking place is in the ground-based infrastructure—comprising launch pads and other facilities—which is transitioning from government to private ownership. This will help the government save in launch services by taking advantage of the increased commonality among payloads on the commercial side. While the Shuttle has many years of useful life left before a replacement will be needed, NASA will continue to upgrade the Shuttle to drive down launch costs. "The role of government [should be] technology development and key infrastructure elements, being a purchaser of services, and supporting regulatory and policy legislation. We in aerospace have a key role to develop and operate new systems, to provide financing, to develop commercial infrastructure, and to provide launch services."

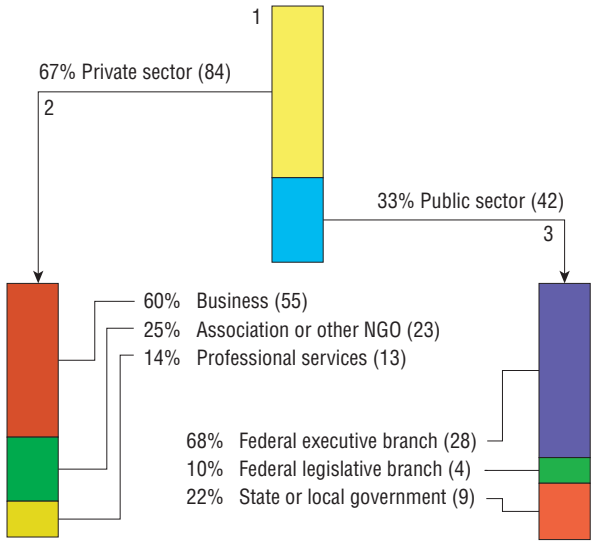
Commercial development will proceed along two main routes, explained Jerry Rising of Lockheed VentureStar: evolutionary and revolutionary. "The evolutionary approach focuses on upgrading existing systems and improving their efficiency, reducing the cost of operations," he said. This includes the EELV. "The revolutionary involves developing the completely reusable system and that is what the VentureStar program is all about."

The X–33 Pathfinder project is a government/industry partnership taking the first step in that direction. VentureStar will be a single-stage-to-orbit (SSTO) vehicle that does not shed stages, boosters, or tanks during launch. After deploying a payload to orbit, VentureStar will fly back to a landing strip and be readied for reflight. Equally important as the SSTO concept is development of techniques and systems that will bring VentureStar closer to airline-like operations.

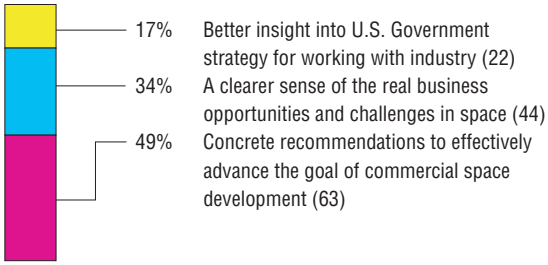
"NASA has primed the pump with a billion dollars of technology funding," Rising explained, "and about a quarter of a billion dollars has come from the industry team. But the next phase will be privately financed. And it is really time for that transition to begin." NASA will continue to fund basic technology—which will be available to all U.S. firms—much as it did for the aircraft industry years ago. But greater technical risk is involved; hence, the need for the Commercial Space Transportation Cost Reduction Act.

Rising said that in addition to a forecast for 1,500 to 2,000 communications satellite launches in the 2000–2010 period, there are emerging markets that include satellite servicing, orbital debris removal, air and space traffic control, power generation, and many others. "This will all be possible by reducing the cost of flying to and from space. Completely reusable systems will reduce the cost by a factor of 10 and ultimately by a factor of 100."

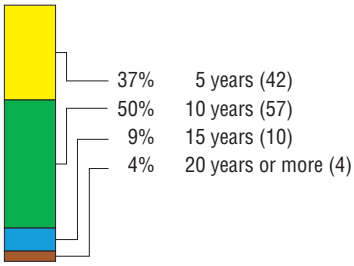
1–3. Please indicate your current affiliation:



4. What outcome of this forum would you most value:

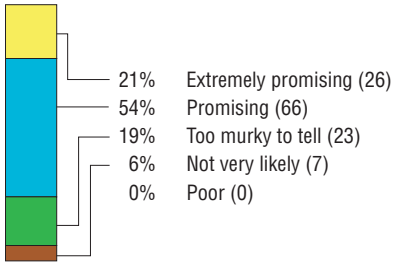


5. In your view, we will begin to see the real promise of space commercialization take off within the next:

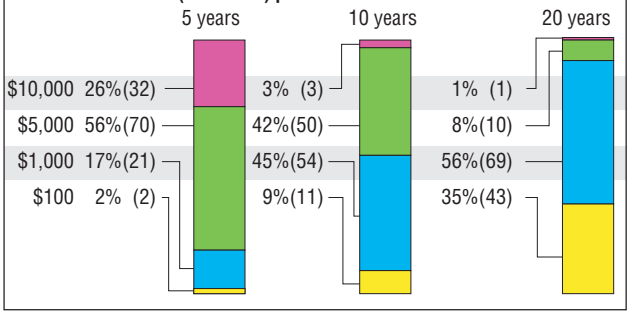


Note: In these graphs and those that follow, percentages are given first, and raw vote numbers are given in parentheses at the end of each item.

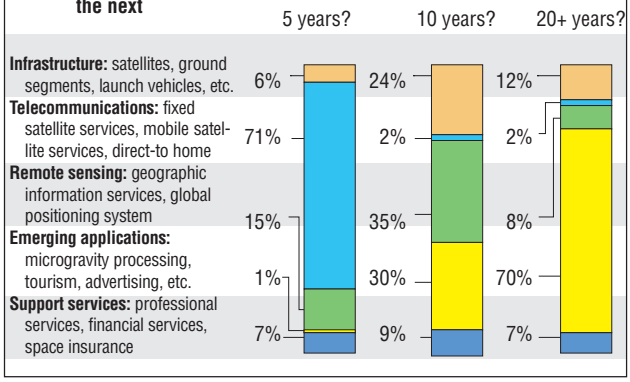
6. Do you believe commercial opportunities over the next 5 years in space are:



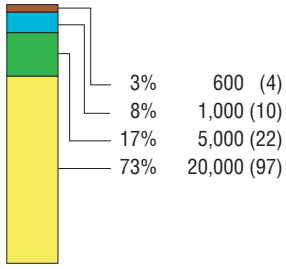
7–9. Launch costs (in dollars) per lb. in



10–12: What sector do you believe has the most business potential in the next



13. What will be the number of humans to go up in space in the next 40 years? (in people)



Panel 1 audience electronic participation results: As part of panel 1, the audience was asked to participate by responding to the above questions. The audience and panelists viewed the results which, in some cases, lead to additional questions or discussions by the panelists.

Microgravity

"In the 1970's we used to say, 'If we can put a man on the Moon, why can't we cure the common cold?'" noted David Rossi of SPACEHAB. "And through space research, we might be able to do that in the very near future." SPACEHAB is a commercial provider of an experiment module that rides in the Space Shuttle payload bay and provides room for microgravity experiments, including those mentioned by Rising.

"SPACEHAB is both a wholesaler and a retailer of microgravity research services on the Shuttle," Rossi explained. "NASA is our supplier, they give us access to space on the Shuttle; they are also one of our customers. At the same time, we are partners getting true commercial companies doing research in space."

As a satellite orbits the Earth, it is in continuous free-fall. The weight (but not the mass) of the satellite and its contents are effectively reduced to about a millionth of what they are on Earth. In addition to letting astronauts float freely, microgravity eliminates a number of effects, such as convection, that distort molten or dissolved materials as they solidify. Notable among these is the growth of proteins as crystals for use in x-ray crystallography to help determine details of their molecular structure. From these images, scientists can develop pharmaceuticals that are targeted for specific functions in cells or viruses. Other research has revealed subtle details of the structure of insulin. This knowledge is being used to refine the design of insulin crystals for more effective delivery in the bodies of diabetics.

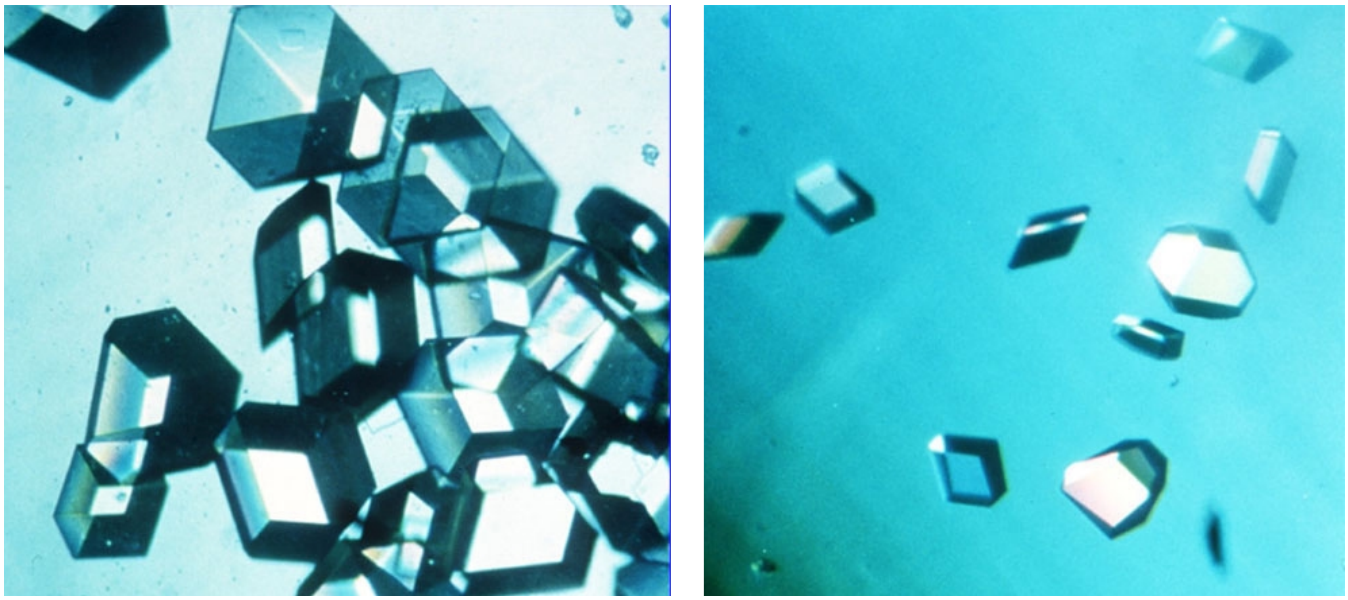
"This is a very big industry," Rossi said. "It is $17 billion a year today and growing by 15 percent a year. Structure-based drug design will eventually supplant the current hunt-and-peck approach to pharmaceutical research."

In a parallel area, NASA is sponsoring research with Bioreactor, a rotating-wall vessel that can gently stir cells to supply fresh nutrients and remove wastes. While in microgravity, cells are more likely to grow in three-dimensional structures—called self-assembly—that resemble normal structures within the body. This will lead to a better understanding of how both healthy and cancerous cells propagate.

SPACEHAB is also involved with a Canadian firm in developing an acoustic levitation device that positions a sample in the middle of a furnace using "fingers of sound" and special combustion techniques that produce porous ceramics for use as bone implants.

The key to turning these activities from research to production is access to space. Most of the work has been done on ≈20 Spacelab and SPACEHAB missions, the equivalent of 2 weeks of research per year for 15 years.

"You could not expect NIH [National Institute of Health] to open up their labs for 2 weeks a year and get good research," Rossi said. "Once we have a space station up there and scientists can continue to do research, perfect their experiments, then we can expect some good results."



Space-grown insulin crystals (left) are larger and better ordered than those grown on Earth (right), thus leading to a breakthrough in understanding the insulin protein's structure.

Remote Sensing

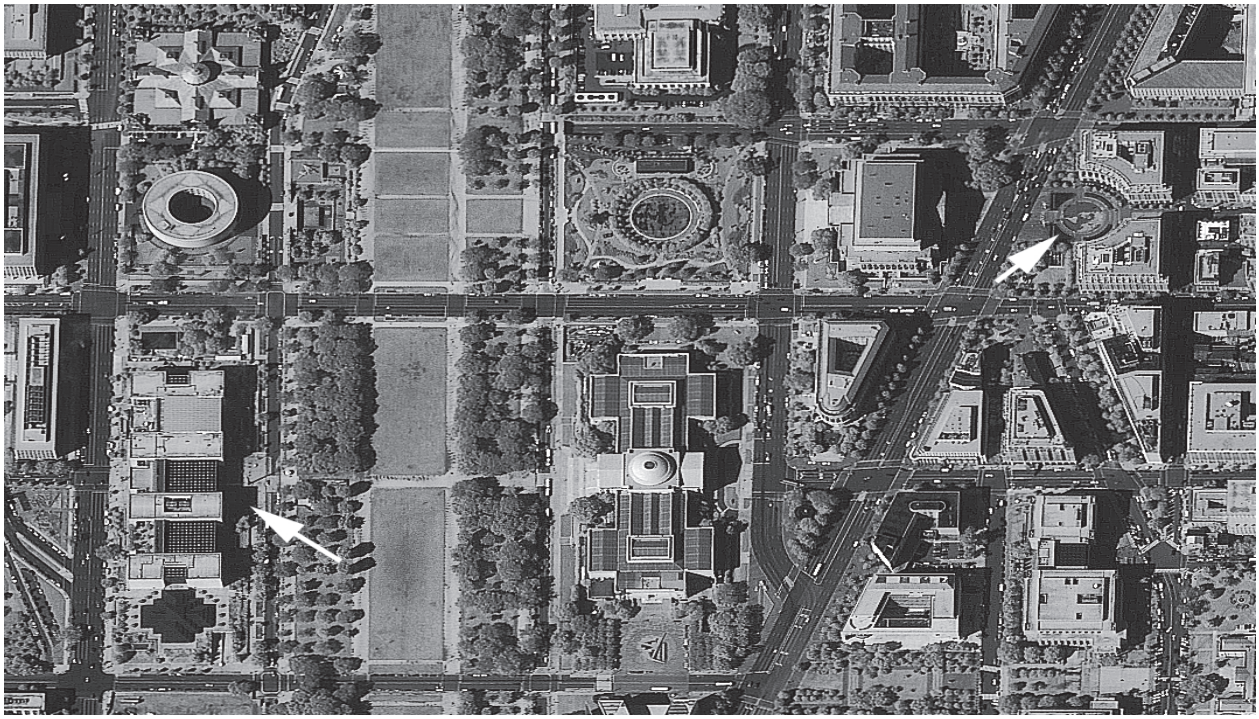
The view from space is both compelling and revealing. One of the early drivers in the space program was the need for both the United States and the former USSR to monitor each other's military buildups without actually entering foreign soil. To this end, spy satellites became highly successful and the stuff of legend. In parallel, environmental observation satellites were developed by civilian space agencies but provided much lower resolution. Only in recent years have resolutions comparable to spy satellites become available to the private sector.

The market for such images ranges from $3 billion to $6.5 billion, according to Mark Brender of Space Imaging. In 1999, Space Imaging launched its Ikonos satellite, which provides 1-m resolution images of the Earth. (Resolution refers to smallest details that can be seen in an image; effectively, these details make up much larger objects that the eye recognizes.) The stunning first image from Ikonos covered a swath from the south end of Reagan National Airport to downtown Washington, DC.

"Some of the businesses that can use our technology are mapping, agriculture, media, exploration, real estate, utilities, civil government," Brender explained. "And there are all kinds of serendipity markets that we haven't even thought of yet." In one case, a large department store chain wants to use Ikonos maps of its 10 most successful stores to analyze why they are successful—in terms of location, parking lot design—and translate that into a template for the design of new stores. Another potential customer is a petroleum pipeline firm that wants to use space images to watch for vegetation changes that would indicate a leak. Imagery can also be used to assess damage from natural disasters and locate where people have gathered to aid relief operations.

"I want to point out that, the satellite at 1-m resolution, you cannot see individual people," Brender noted. "You can not recognize individual people. This is not *Enemy of the State* [a 1998 movie about spying on private citizens]. This is a commercial imaging satellite that is outside the threshold of personal privacy." He also detailed how "the U.S. Government has their finger on our shutter." Where national security or foreign policy is concerned, the Government can restrict taking images of certain areas. Nevertheless, the potential uses are immense.

"The best thing about our imagery—unlike someone who wants to order this pen over the Internet—you can order it over the Internet but it has to be shipped to you," Brender continued. "Our technology is digital data. … We hope that one day this technology will be as indispensable to society as handheld cameras and the printing press are to free societies."



A portion of Space Imaging's stunning panorama of Northern Virginia and Washington, DC. Near bottom left is the National Air and Space Museum; near top right is a circular mosaic of the world at the U.S. Navy Memorial.

Near the edge of space, tourists experience weightlessness aboard a Russian cargo jet that provides ≈20 sec of low-g, just as it does in cosmonaut training.

Horizon Market Opportunities

Because space images are so compelling, as is the prospect of floating free as astronauts do, space is attractive as a tourist destination. The booming global economy has made travel and tourism a $515 billion industry with growth of 6 to 7 percent per year. Space travel, said Gloria Bohan of Omega Travel, is becoming "an important niche market" within the $5 billion adventure travel business. She stated how 10,000 people a year visit Antarctica, and some 35,000 in total have visited Mount Everest (only 600 have made it to the top; 140 died in the process). Adventure travel packages cost $30,000 to $100,000 per person, so a modest reduction in space flight costs could open space as a new niche market.

"I think one of the biggest challenges that we have is attaining credibility," she said. "There is serious consideration that needs to be achieved in the media and the public eye. Of course, there has to be success in the development of less expensive RLV's."

As an intermediate step, Omega Travel and its partners have developed Space Adventures, providing several "Steps to Space." These range from conventional tours of space facilities on Earth—such as the Very Large Array or Kennedy Space Center—to the "Journeys to the Edge of Space." These include rides aboard a Russian aircraft flying parabolic trajectories to produce 20–30 sec of near weightlessness or flights aboard a MiG–24 Foxbat jet fighter to high altitude.

"The final step is the suborbital space flights," she said. "Flights would be made to at least 100 km, astronaut altitude. And there are several serious RLV projects underway. Some anticipate flights within 2 to 3 years."

Bohan also sees advertising in space as a potential market, especially given that many advertisements use space as a theme to attract the reader's eye or to promote a product's advanced features.

In a few years, Bohan predicts, low-g flights will be available in the United States: passenger RLV's by 2001–2002, followed by 500 reservations per year for suborbital flights. By 2006, RLV's will carry passengers to orbit and make long-distance suborbital business travel and package delivery possible.

PANEL 2: WHAT ARE THE CHALLENGES TO COMMERCIAL SPACE DEVELOPMENT?

Along with the many opportunities offered for and by commercial activities in space, the would-be orbiting capitalist faces a number of nontechnical, and nontrivial, hurdles in using the space environment for financial gain. Even beyond the obvious need to reduce launch costs, several policy, legal, and financial issues must be overcome. The four questions selected for the panel to address were:

(1) What is the biggest barrier facing commercial space development?
(2) What is the biggest business deterrent?
(3) What sort of government encouragement, if any, would be best?
(4) What is the main driver toward investment and initiating a new commercial activity?

Policy

For most of the Space Age, the amount that the U.S. Government would spend in space has framed most discussions, and the health of space activities was measured in terms of the size of the NASA budget, regardless of how much was being spent by the Department of Defense (DoD) or other Federal agencies or by the private sector. As outlined by Robert Walker, president of The Wexler Group and former Chairman of the House Committee on Science, it is both a policy and cultural issue as to whether the space commerce revolves around the percentage it holds in the Federal budget or in the Gross National Product (GNP).

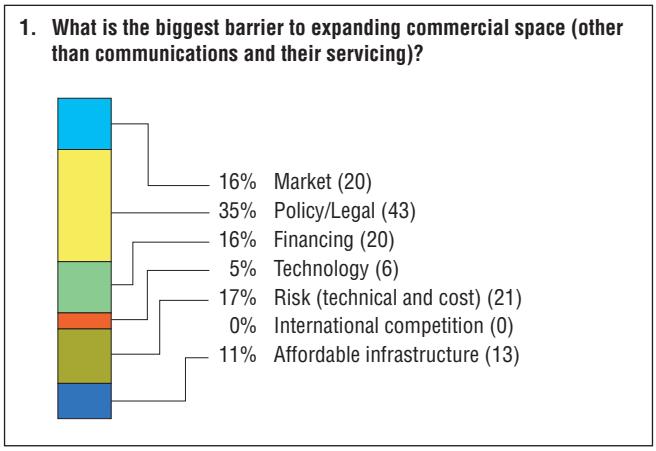
"Today, what we have got to do is move out of that realm and consider the Federal budget as only one piece of the overall investment that is taking place in space," Walker said, "and understand that if you have policies that are allowing an increase in the percentage in the GNP that is being invested in space, then you are winning."

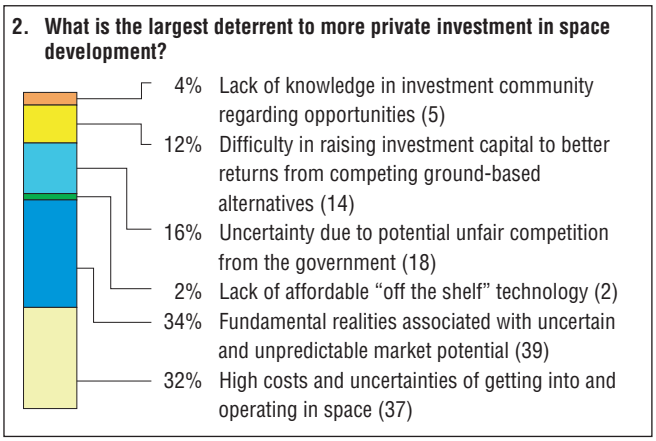
An important factor is understanding the difference between the industrial policy that dominated through much of the Cold War, and the investment policy that has been evolving over the last decades. The Apollo program, National Atmospheric and Oceanic Administration weather satellites, and other projects are tied to the Federal budget.

"The policy alternative is to look for an investment policy," Walker said, "and figure out what it is that we can do that will encourage people to bring forth investment, even if the government is not willing to look at a particular kind of business enterprise."

In this way, government becomes an enabler rather than an implementor. In addition to investing money in research and development that produces new technologies for use by American industry, Walker recommended tax incentives, including tax cuts, so that profits from products developed in space are tax-free.

"For example, Representative Dana Rohrbacher promotes an idea that says that tax treatment comes after you have developed something that doesn't now exist," Walker said. "So that if you develop something that becomes a profit in space, then the profits become tax free, after you have actually put the development in place." Since few products would come on line within the 5-year limit set by the tax cut, what "you get is a policy that actually drives the investment but doesn't cause you budget problems." Other techniques include cutting interest rates and providing loan guarantees.





Panel 2 audience electronic participation results.

"And then you also have to accept things that are purely commercial and that may not fit with national priorities," he said. Here, the national priority would be that the business grows while government supports it with incentives and proper regulation. It is a cultural change that will be difficult for people to accept, he acknowledged. A final step is that the government can become a purchaser of space-derived goods and services.

"Not a guaranteed customer up front," Walker said. "Because too often in industrial policy you end up picking winners and losers. And that won't work if you are going to grow the enterprise. But if, in fact, government is a known customer for that which you are going to bring on line and you can come up with the right price, it seems to me that is a huge incentive for investment."

A final area where help is needed is coordination of space activities among the many Federal agencies that have space roles. Of crucial importance is having regulations that are efficient and do not block progress.

"If we do all those things in the overall framework, we will have a policy that works," Walker said.

Technology

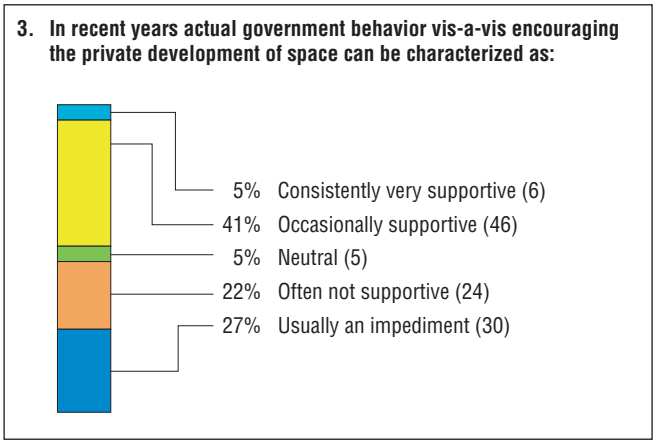
Even so, much of what happens will be driven by the availability of the right technologies. In this arena, observed Joel Porter of Lockheed Martin Astronautics, there are three primary customers, each with different needs. The DoD wants to gather information from everywhere and then project force into hostile areas. NASA wants to collect large volumes of scientific data with systems that work for years or decades, often unattended. And then there is the private sector.

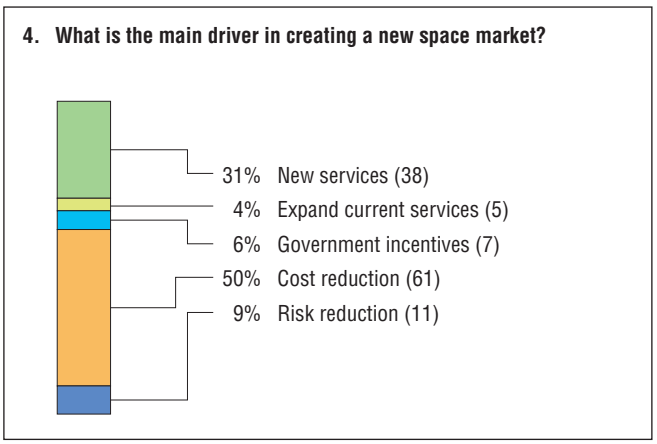
"What are our commercial customers looking for?" he asked. "They are looking for affordability, but affordability as they define it." The system must be highly reliable and ready to go when the customer wants to go and must be able to fly on whatever carriers are available. And always, they want decreased weight and cost and increased bandwidth and resolution.

"You have to do some very careful analyses of your down side to understand what risk you are taking, because it can very quickly take your business plan," he explained. "So again, my thesis is that any technologies that are going to help reduce costs will help sustain that investment and take out some of the risk and uncertainty of the market side and that means decreasing weight, increasing life, and providing more product per pound per dollar." And while reduced launch costs are a key concern to NASA and DoD, "I can't see any business plan that would not accept any lower numbers in the business plan relating to lower weight, therefore driving the launch vehicle cost down for that particular project." In addition, longer life and greater reliability are needed to reduce the replacement of assets in space. Some technologies will be shared by government and business, while others will be developed by business not wanting to wait for the government to decide. Examples of advanced systems include harnessless and connectorless subsystems that will save a tremendous amount of weight and volume, sensors embedded in the structures to provide active control, and new energy storage techniques such as flywheels. Satellite communications may become more like the Internet.

"It blows away the whole approach to serial data streams that we have been using for 35 years to talk to spacecraft," Porter said. "This way you will talk to spacecraft just like you talk to a computer on a network down the hall or in another city or another country on the Internet." Other areas that need advanced development are intelligent sensors built into systems, lightweight coatings, and integral structures that reduce the mass fraction of a vehicle.

"In our view, the biggest challenges are not only technical, though; they are cultural because to make the vision real we





Panel 2 audience electronic participation results (continued).

have a dilemma on our hands," Porter continued. The dilemma is that space must be made exciting and routine at the same time. Finding the balance will be challenging.

"The most important thing to take away is, to date, commerce and technology, from a space perspective, have been advocated by those of us who build space machines in this industry, and that has to change," he concluded. "It shouldn't be us that are advocating building these products. It should be the people who can make money on using these products outside of our industry and who come to us for help and support to see if they can close their business plan."

Finance/Insurance

Two major factors in every business plan are the risks of losing all the money that has been invested and injuring uninvolved third parties.

"The cost of risk is absolute; you can't escape it," said Rick Hauck, president and CEO of AXA Insurance and a former astronaut. "And the question is, How do you allocate it? How do you mitigate it? Can you transfer it? … You can retain the risk, that is, you bite the bullet and say, I'll pay whatever it costs. Or you could transfer it, and in this terminology we mean buy insurance, and your premium going into the insurance company is pooled with everybody else."

Insurance, he explained, makes the cost of risk manageable by spreading the financial impact over a large pool of investors. The cost can be especially large in the space business where a single satellite carries a high price, not only in the craft itself, but in the planned revenue stream for the next 5 to 10 years. Space insurance typically covers the physical assets, property, and people that might be hit by a launch failure and the revenue stream (if this business line is established and has a documented history of success).

Hauck cautioned that a key concept in the insurance business is the amount that could be lost in a single event, which, in the space launch business, could be as great as $1.2 billion for a single launch and could be done many times a year.

"The key there is the expectation on the part of the insurer, that your losses will be payable from the premium flow coming in," he continued. "You can do the math very quickly and see that with too many failures and loss of confidence on the part of the insurance market, then I am going to put my money elsewhere." As a result, insurance companies spread their risk across a pool of investors.

Globally, about 20 percent of insurance comes from the United States, 45 percent from Europe, 24 percent from the United Kingdom, and the balance from other nations. Because of this international base, technology transfer becomes a concern. If a firm is to write an insurance policy, it will want some insight into the technologies and systems being used so it can understand the risk.

Other challenges facing the insurance industry include generic failures that can affect a constellation of satellites already in orbit and natural and manmade environmental hazards (including radiation and solar storms in the first case and mainly rocket debris in the second). The Y2K computer bug was not expected to have a major impact on space operations.

Hauck cautioned that space insurance is a volatile business. Over the 1990's, the business has been profitable. Over the last half decade of the 1990's, it has lost $125 million, mainly because of losses in a single year. Premium rates have gone from as low as 7 or 8 percent in the early 1980's to as high as 27 percent in the mid-1980's.

"We try to discriminate against risks," Hauck said. "Those of you who have good success in launching rockets and operating satellites, you should not have to pay as large an amount for your premiums. But this is a commodity now, at least the way it is priced now, so don't be surprised that if we have bad results, whether you personally have good results or bad results, you will be impacted by any major problems."

Future markets for space insurance include supporting government programs in which the manufacturer is contracted to deliver a satellite and government ownership does not commence until the satellite is on-station, and horizon markets like space tourism and reusable launch vehicles.

Legal/Space Law

Until recently, the biggest barrier to commercial reusable launchers was space law.

"I shot an arrow into the air; where it falls, oops, it can't fall because no one can give me a license to bring it back down," explained James Dunstan, an attorney and partner in Haley, Bader and Potts. "In the 1998 Commercial Space Act, Congress specifically provided authority to the Associate Administrator for Commercial Space and Transportation to issue regulations and license reusable launch vehicles by adding the term 'and reentry' into the appropriate parts of the U.S. Code. The purpose of the bill was to encourage the development of a commercial space industry by streamlining government regulatory procedures."

Nevertheless, challenges lie ahead. Licensing to date has involved ELV's headed from a coastal launch site over the ocean.

"We have got to get more toward a system-based mentality where we look at, overall, a vehicle that is going to fly many times and determine whether or not it is in fact safe to fly," Dunstan said. That safety factors into whether the vehicle can be launched so it passes over land where people will be under the flight path. The ultimate "Catch 22" challenge will be "how do you get the licensing to fly mission flight Number 1 when you haven't got the track record to prove that in fact it is safe enough to launch?"

A challenging aspect is liability. Under U.S. law, launch companies must carry $500 million in liability insurance, and the U.S. Government covers the next $1.5 billion, because launching a rocket is considered an ultrahazardous activity and the launcher is automatically liable, as compared to most insurance where the injured parties must prove negligence before they can collect.

"Now, what is wrong with this picture?" Dunstan asked. "Does it make any sense?" Placing it in context, he noted that about 50,000 people a year die on U.S. highways, and fewer than 2,000 in aviation accidents. "Yet we license these activities. We let people drive around, we let them fly around in planes, and we lose that many people," he continued. "How many people have we lost in space? Seven, and it always gives us a big lump in our throats because of a horrible tragedy. Seven people." By comparison, during the nearly 3-year stand down period after the *Challenger* tragedy, 120,000 died on the highways and 1,200 in air travel. In another form, he noted, the 1929 Warsaw Convention for Air Traffic limited liability for air crashes in order to protect the industry's growth. The accident rate at the time would project to 250,000 deaths a year at today's passenger mileage. "The fact of the matter is that we are a risk-averse people and a nation of victims and until we are ready to accept societal risks similar to those in automobile and air travel, we will never become the space-faring civilization."

Space business will soon have difficulties in the area of frequency allocation in the radio spectrum. "We are approaching a train wreck in terms of satellite frequencies issues," Dunstan said. "We have a set of current policies that are severely hampering our ability to do anything in space in the next few years. Almost all the Earth-to-space and space-to-Earth frequencies are being gobbled up by big LEO's, little LEO's, big GEO's [geostationary Earth orbits], all the communications satellites." Even commercial communications with the Moon have no frequencies set aside. At the same time, the government is privatizing much of the spectrum by auctioning the rights to many frequencies. "So anybody who is doing something that is not in the telecommunications business is not going to have a chance at any of those frequencies," he continued.

Finally, he said that "significant work," possibly clarifying legislation, has to be done to figure out how NASA will acquire scientific data from commercial sources under the terms of the 1998 Commercial Space Act. Dunstan expressed little concern over property rights, saying that the principal thing to watch for is everyone assuming that NASA is doing everything, as witnessed by *Scientific American* putting the NASA logo on a picture of the privately developed Roton rotary rocket.

Public/Private Roles

Still, there are interesting legal problems for commercial companies that try to get involved with NASA projects. This involves the search for "Murray," a single manager or office that can handle all queries, requirements, and paperwork. The challenge was outlined by real estate developer Robert Werb of Orbital Properties LLC in New York City.

"This story starts in December 1997 when NASA flew something which they called AERCams (Autonomous Extravehicular Robotic Cameras) and we called spacecams. The idea of these things is that they are going to cut down on the EVA time needed for the *International Space Station*," Werb explained. Spacecams could serve as minispacecraft with cameras and lights. A prototype was flown on the Space Shuttle in 1997.

"My partners and I immediately perceived the market opportunity," Werb said. "We looked at these images and said people would pay us for these images. … The key here is that it has no new technology and little technological risk. And we're proposing a bartering arrangement to NASA, where we use our own money to take over the development and construction of the spacecams and greatly simplify the arrangement."

In a different partnership, he is working on a 300-unit townhouse-style apartment on Staten Island. Working with a broker, he found an attractive piece of property "that happens to be owned or controlled by a guy named Murray." Werb and his team worked the details of the purchase with Murray who in turn works with his partners.

"In the spacecam deal, there is no Murray," Werb explained. "There is nobody to make a deal with." It took visits to NASA Headquarters and to Johnson Space Center to turn up the right people to deal with and then to determine that an unsolicited proposal was needed. But implicit in that is a request for money from NASA.

"But of course we don't want NASA's money. We just want to make a deal," Werb continued. While the NASA

AERCam—the "beachball" at the center of the main image—was given its first flight test on the STS–87 mission in 1998. The images at bottom were taken with the AERCam.

people are supportive and well intentioned, they have to operate under institutional constraints that they alone cannot change. Normally, his company would proceed next with a handshake agreement and then with a basic contract. In the real estate deal, Werb will deal with Murray and others like him. At NASA, he is not sure of the status of his project or what form the deal may take.

"Do we have a contract with them when we are done?" he asked. "If we have a contract, who negotiates it on NASA's behalf? Who would sign such an agreement? Would it be binding on whoever takes over operation of the *International Space Station* after NASA is done? I don't know."

Going back to the real estate deal, Werb cited a range of City and State building, fire, and labor codes he will have to

follow—some good, some bad, but clearly known by all parties. But at NASA, the comparable criteria are those of the Safety Committee, which has no easily found written requirements: "I don't know how to deal with this from a businessman's point of view. … We are working on a fixed budget. How do we go in the beginning not knowing what our safety constraints are on the back end?"

Financing is another challenge. While initial funding will come from his own checking account, he will want to borrow money to finance the project. In the real estate deal, Werb will have a bankable contract and a title that an insurance company can check at the Registry of Deeds to ensure that the deal can be made.

"How exactly can I establish clear title to my own equipment after it is bolted onto a truss on the *International Space Station*?" Werb asked. "I don't know. Can our contract with NASA ever be bankable? I don't know. I don't know the answers to a lot of these questions. But I do know that if there is ever going to be any significant amount of commercial activity on or around the *International Space Station* we are going to need the answers to these questions."

Ultimately, Werb argued, the role of government in space should be the same as it is on Earth: "The government's job is first and foremost to be a regulator and secondarily to be an enabler. … Unfortunately, because of an accident of history, government has assumed a much larger than normal role in space. The question is not what is the proper role for government in space. The question is, 'How do we return government to its traditional role?'"

PANEL 3: WHAT MUST BE DONE TO MEET THE CHALLENGES FACING SPACE DEVELOPMENT?

"Now what?" asked Warren Corbett, managing editor of United Press International's broadcast division, at the opening of the final panel discussion of the forum. Given the technical and policy challenges outlined by the previous speakers, "Our task is to look at some specific options to promote and move forward the cause of commercial development in space. What do we do now?"

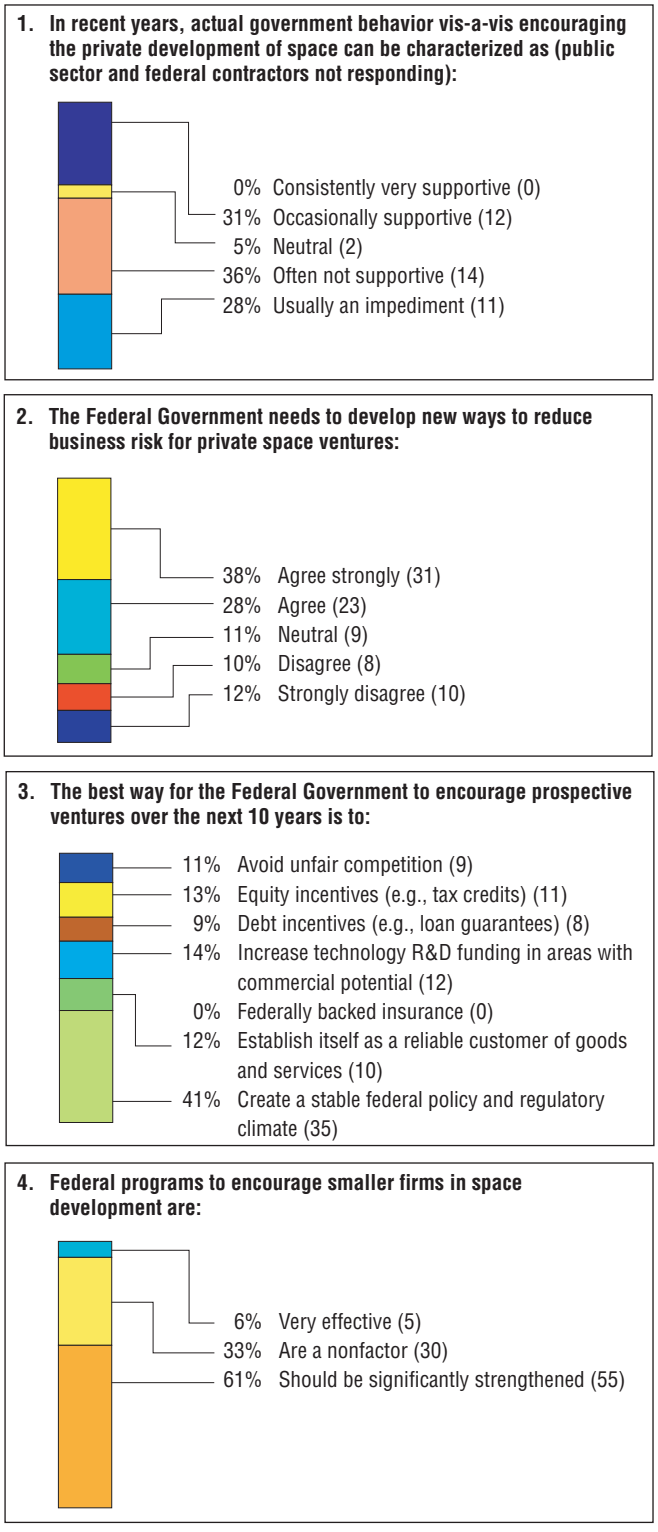
To sort through the options, the Chamber selected a panel: Apollo 11 astronaut Edwin "Buzz" Aldrin, now chairman of StarCraft Enterprises; Shubber Ali, manager of Space Strategy Consulting Practice at KPMG Peat Marwick; R.V. Davis, president of R. V. Davis and Associates and a former Deputy Undersecretary of Defense for Space; Charles Lauer, vice president for business development at Pioneer Rocketplane; Alan Ladwig, a senior advisor to the NASA Administrator [he has since left for private industry]; Ed Tuck, managing director of Kinship Venture Management, a venture capital firm; and Rick Tumlinson, executive director for the Foundation for International Non-Governmental Development of Space.

Goals and Priorities

The panelists agreed that human exploration is one area that is not likely to be commercialized in the near term.

"I see where you can begin to do that with Shuttle operations because there … the commercial sector can supply to NASA and to other commercial entities," Aldrin said. "But in the field of exploration, the payoff doesn't really look like it is going to provide much incentive for commercial investment." In response to the question of how to define privatizing, Ali offered that if it means simply taking over a government function and the government remains the principal customer, "then it probably won't do a lot of good to spur the commercial market place."

Still, Davis suggested, things can be done to reduce costs. Although most expendable launches from the United States are for the Air Force, he sees no reason why the Air Force should operate both Cape Canaveral and Vandenberg Air Force Bases. "At this point I think there are a lot of people's companies that would love to get the chance to compete and operate Vandenberg and the Cape," he said. "So there are very clear things that could be done today to proceed to privatize these facilities and that is the wave of the future. It may take us 20 years to get to a point when a small percentage of the launches are U.S. Government."



Panel 3 audience electronic participation results.

The Delta launch pads at Cape Canaveral are operated by the U.S. Air Force, but do not necessarily need to be.

Ladwig noted that NASA Administrator Goldin is committed to hand over operational facilities to the private sector. Yet, "how do we go about turning this over to the private sector, especially the operational stuff because he wants to free up funds then for other exploration activity?" Tuck continued that where systems are "generating revenue, it doesn't make any sense for the government to be in the business."

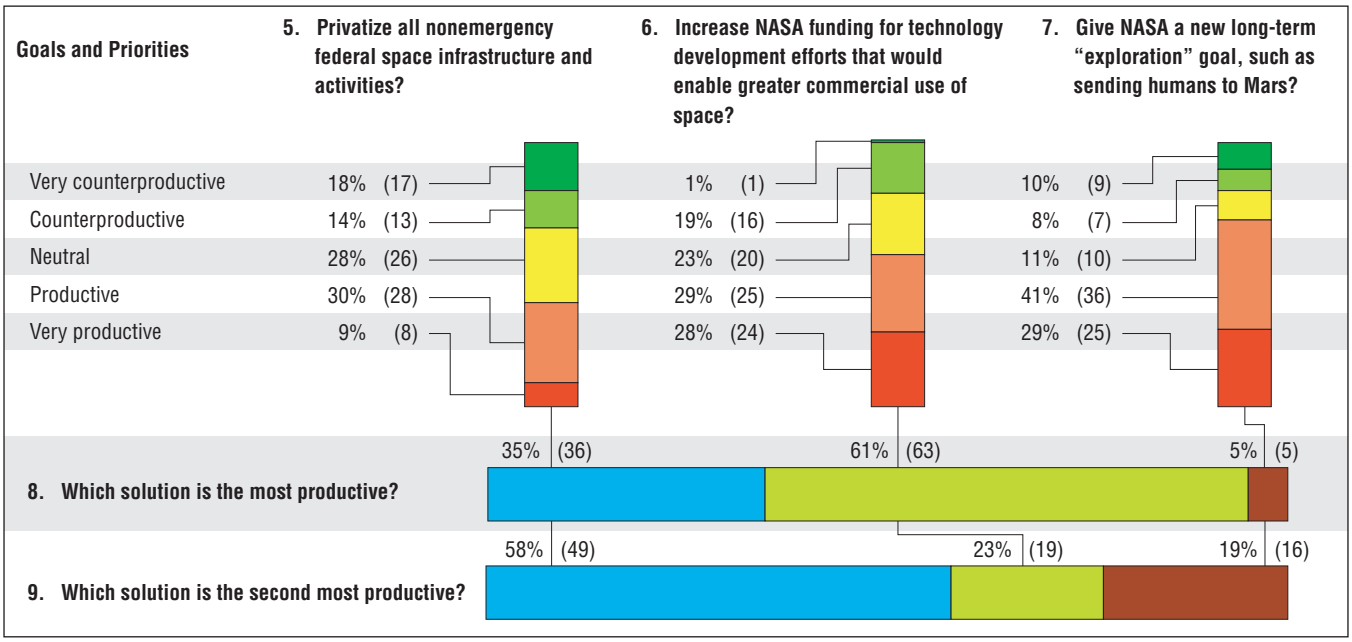
A potential area for NASA to help is in developing technologies that would help commercial ventures. "You can always say increase the [technology] budget, but is that necessarily the magic bullet?" asked Corbett.

"I think in the case of some of the [R&D] companies that we are working with," Ali responded, "what seems to come out most beyond government regulations, which is something that you can change, you need to lower the cost of access to space." It holds for many applications. "And if NASA can help lower the cost of launch through X–33, X–34, or any other program or enable the private companies to lower the cost of launch, then yes, it would be very practical."

But "technology" covers a lot of terrain. "The real minefield in that question," rebutted Lauer, "is when you're saying funding for technology development, how do you do that without getting into the picking of winners and losers?" As technology becomes more applied or specific to a given vehicle or system—and therefore to one company—"you get anticompetitive forces working at it, too."

Tuck expressed concern that the *International Space Station* program has become an entitlement program within NASA's budget and thus will "suck all the money out of technology development." A possible solution, said Tumlinson, is for the government to invest in technologies that are fundamental and not even near competition. Yet picking winners and losers is not always bad, Davis countered. The government does it every day through competitive contracting.

"If the government is going to lead in some of these areas," Davis continued, "and there is a fair opportunity for competitors to bring their product to the table, if the



Panel 3 audience electronic participation results (continued).

government is going to lead, they do indeed need to be involved in picking winners." Corbett drew an analogy to the U.S. Air Force selecting Boeing to build a cargo jet in the 1950's. In civilian form, the KC–135 became the 707 and revolutionized air travel. Yet Tumlinson considered that it would be anticompetitive for the government to pour money into one competitor at the expense of another, especially when small companies such as Rotary Rocket are using their own money.

"The things I do are generally conceded to be off the wall," Tuck said. "And I doubt if I could have persuaded the government to fund any of the things with the companies I have started, simply because it is not the kind of thing that lends itself to committee action. So if they can pick winners, that's fine, but it is nice to have some source of funding out there for people who are crazy enough to start stuff that nobody would fund."

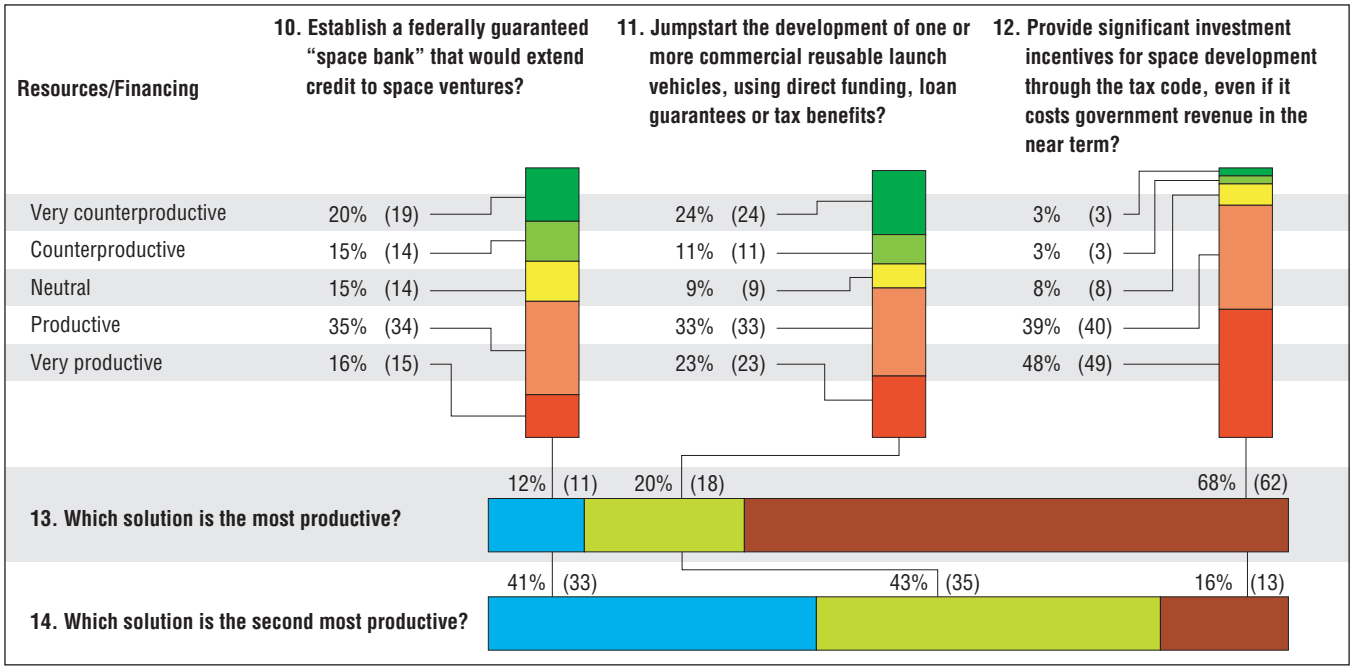
A possible solution for getting NASA out of competition is to give it an overarching goal, as was the case in the Apollo Moon Landing program. Corbett noted that setting a goal also drives a range of technologies.

"It isn't just that," Tumlinson said. "It's a matter of focus, and one of the things my industry has been talking about for a while is redefining who does what; so getting NASA to go out to Mars, into the far frontier, staying out of the near frontier, first of all gets them out of the hair of the private sector in a sense. But the single goal is not widely endorsed even within NASA."

"I think the single goal is the most idiotic thing I have ever heard," Ladwig said. "As you are going into the new millennium, the thing you don't need is a single goal for NASA. That was OK in the Apollo era, during the Cold War, because there was a political imperative offered by a president, who said, 'What can we do to beat the Russians?' NASA came back with DoD's advice on a scientific and technical opportunity, which was, we can go to the Moon and come back. There was national spirit involved because the public didn't like being beaten by the communists in this race for the Moon. And those three factors have not been in alignment since then."

The fourth factor now in play is economics, and no one has yet figured out how to make that work with manned Mars missions. In addition, Ladwig continued, NASA has four enterprises: Space Science, Earth Science, Aerospace Technologies, and Human Exploration and Development of Space. "And why should you force all of those into a single goal that I don't think is going to happen anyway? So I think this 'magic bullet of humans to Mars is the answer to all of our problems' needs to be debated a lot more, looked at a lot more, and we simply have not laid the ground work."

Yet in the age of the 15-sec sound bite and short public attention, it was suggested, a single goal can have a cohesive effect and can benefit the other activities.



Panel 3 audience electronic participation results (continued).

Resources/Financing

So once you decide what to do, where do you get the money? It will not be easy.

"Space projects are a lot more expensive than normal projects," Tuck cautioned. "They need a half a billion to a billion dollars of capital … before you can ethically go out and sell stocks to widows and orphans. You can't fund these things ethically until you have something that seems like it's going to work, and it takes a lot of money to get there."

"Most venture capital-funded deals fail—loan programs are good for low-risk projects and tax credits are for late-stage investors, not early-stage," he said. "I think what we need is something to fill the gap between the $50 to $100 million that a venture capital syndicate can put up and the half-billion to billion dollars that makes sense to take it out to the public or to get loans." Tuck recommended "three really mega-venture funds that are dedicated to space with a billion dollars apiece in them. And I think the limited partners in those funds should be the governments." The fund spreads the risk over several investments and ultimately recoups its investment and some profit so the process can continue.

One concern is that even though the investment would be recouped, it would set aside money that would not be available for other purposes. And getting to the bank might be a problem because, Ali noted, "…a lot of startup companies … can't even get startup venture capital from the startup venture capitalists in the early stage."

Lauer noted that space ventures are capital-intensive, more analogous to the real estate industry than to the software industry or the Internet. The launch industry is just a service industry to telecommunications, he argued, because launches ultimately are paid for by individual telephone calls. "If you brought down the cost of the capital by making the interest expense tax free to the lenders, that effectively reduces your cost of capital by one-third right there. There are lots of different mechanisms you can use to finance projects, but something needs to be put in place."

One option is for the government to jump-start the development of commercial RLV's by direct funding, loan guarantees, or tax breaks.

"What does the government really need to do?" asked Davis. "Well, the barriers to get into space in some cases are just simply proving flight hardware. And NASA and DoD do have programs to get flight hardware proven in space, and then in many cases, that is what it takes to get the commercial world to start using it in the commercial sense. So that is one area, but that's not necessarily a large funding area."

Starting an RLV venture will be very expensive, he said. "I don't know how we would do it without the government, somehow, stepping in and doing it, whether it is tax incentives or a bank, but it needs to be very few and very selective. And, yes, in that case, the government probably will pick a winner, but there will be competition for anyone who wants to come to the table and bring their models the next time." The downside, Tuck countered, is that it would make competition difficult

and that it is impossible to tell a good deal from a bad one at the start. "So the chances of the government, with its political and committee form of operation, picking a loser, is, in fact, pretty high. And it makes it awfully hard for those who would have been winners to compete in that circumstance." Ladwig said that success can be assured by having several irons in the fire.

Having the government act as an anchor tenant—like a major chain store being the first to buy space in a new mall—would help attract other buyers for a new vehicle, Davis suggested. "If you look at the launch industry, a big space house like Hughes went around and was merrily awarding contracts ten at a time for launch and helped put some launch vehicles on the map, frankly, in doing that." This would involve Contingent Purchase Contracts in which the government cannot now engage. But, "it doesn't necessarily cost the government a dime to be able to go out and say that if you build a reusable launch vehicle, we will come and we will sign a piece of paper that you can take to the bank, that if you can make this thing work and the risk is yours and the bank's, we will agree that we will launch if you need functional parameters."

The last option discussed was the value of investment incentives, even if they cost government revenue in the near term. Achieving it would be easier, Davis believes, than putting a $1 billion line item in the budget. Ladwig noted that Orbital Sciences Corp. "started out of a quirk in the tax code in the early 1980's for R&D tax credits. Its advantage is that the government is not involved in the decision. Anybody that makes the deal under the regs qualifies for the same tax treatment. There is no government board that you have to pitch to get it. So in that sense, it lets the business community decide where the money is going to go to and provides effectively a lower cost of capital by taking it off the taxes."

Public/Private Sector Roles

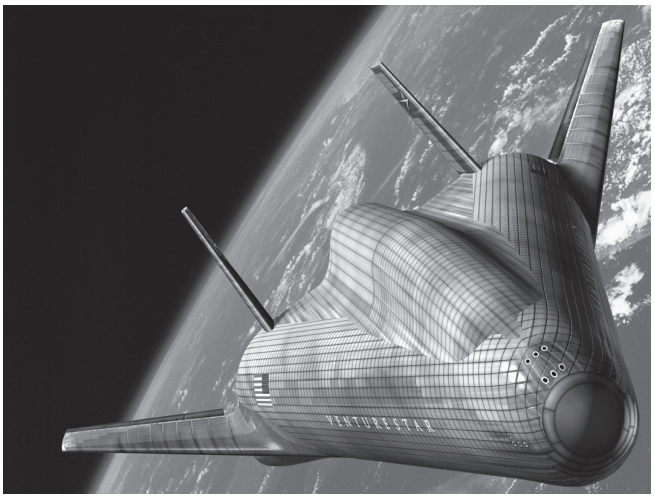
So who gets to be in charge if NASA is to step away from running the *ISS* and other activities near Earth and focus on the Moon and beyond? Two examples of success are the Jet Propulsion Laboratory (JPL) and the Space Telescope Science Institute (STSI). JPL is often mistaken for a NASA Center when, in fact, it is one of the earliest government-owned, contractor-operated (GOCO) facilities in the aerospace business. In this case, the operator is the California Institute of Technology. STSI is operated by the Association of Universities for Research in Astronomy (AURA). Similar models of nongovernmental organizations (NGO's) have been proposed for the *ISS*.

"I think we're open to how we turn this infrastructure over to a non-NASA entity to run," Ladwig said. "Whether it is an NGO or a private company, I certainly don't think that has been decided and I believe we are certainly open to that." But it will depend on the intent, Ali countered. Most NGO's are nonprofit organizations. If the intent is to commercialize *ISS*, then it should be placed in the hands of a commercial organization. "But then it raises a lot of questions that will have to be addressed both by government and just general opinion in terms of did we build an asset in space just to let a company make a profit or did we build it for R&D or what was the purpose of Space Station?" Ali continued.

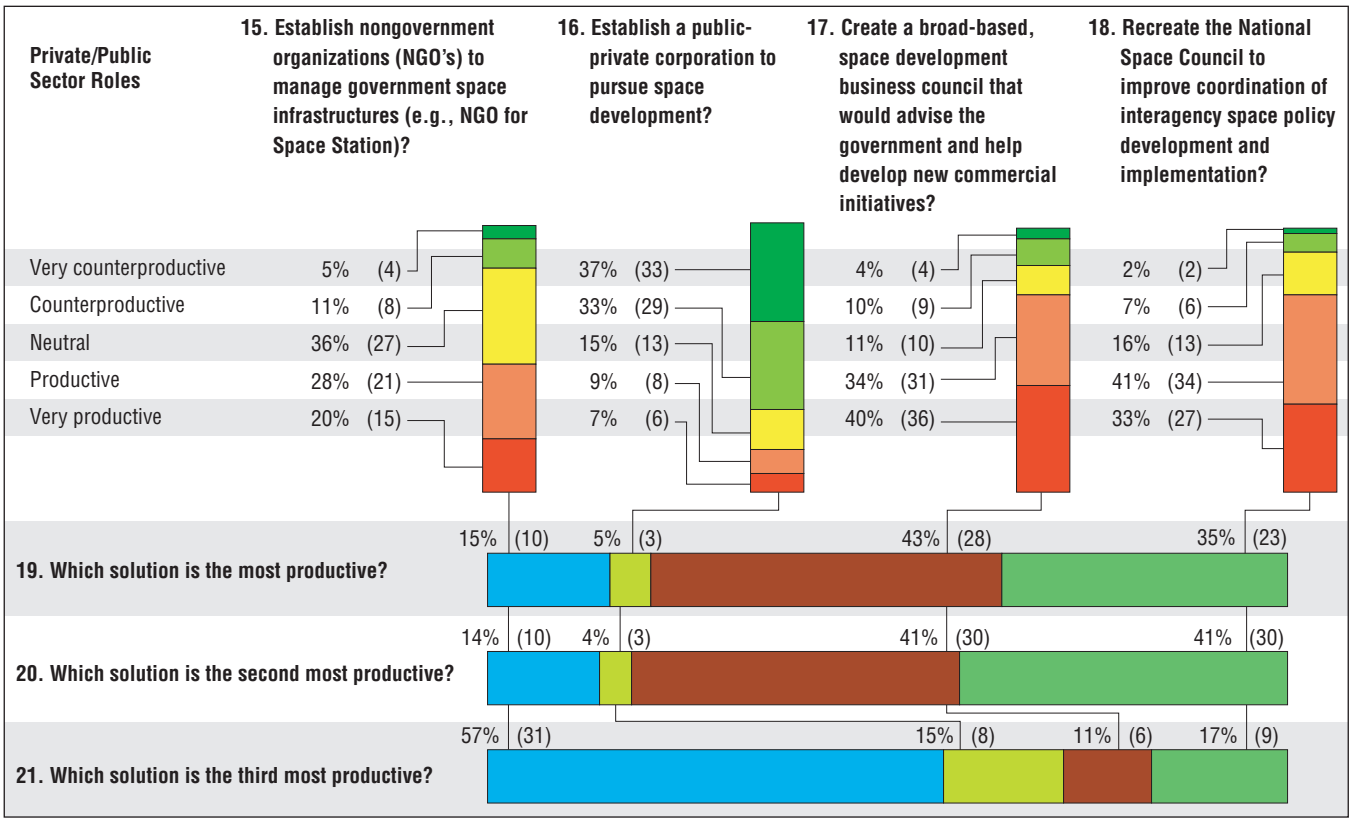
Tumlinson suggested a middle ground, a quasi-governmental operation akin to the New York Port Authority, whose goal is to increase economic productivity and is judged by that result. "The JPL model to me would be perfect for that element of NASA that has to work with the Space Station, in other words to organize NASA's activities on the Station," he continued.

Ladwig approached a basic issue that was raised earlier. "I think you need to be able to have a mechanism that first of all, there's Murray, and you can actually sit down with somebody and negotiate a deal." And the deals need to include licenses and royalties so the government does not just write off the cost of building the *ISS*.

"But I think there needs to be the ability to do royalty deals, licensing deals, where the government isn't just writing off the sunk cost of the Station and only dealing with marginal costs of operations. There should be some way to get some money back into the deal and to be able to have money come back into the system." That does not happen now because the money goes into the U.S. Treasury without any benefit to NASA.



Moving from the X–33 prototype to an operational VentureStar, shown here, will require extensive financing.



Panel 3 audience electronic participation results (continued).

"One of my goals with the port authority idea is to sort of remove the interested parties such as NASA and the space agencies one step so that they become customers," Tumlinson replied. "You might have this port authority, then hire a consortium to actually operate the Station, with the mandate being producing a profit."

Ali cautioned that the port authority analogy is limited because the transportation segment is still government subsidized, and no commercial operation owns the trucks and buses that will pass through it.

Another option is the COMSAT model, a public-private corporation like the one that helped start the communications satellite industry in the 1960's. Corbett conceded that "it makes people wince," and Aldrin voiced concern that "it really leaves out the little guy because the government is going to deal with the big entity as a joint venture." Yet another option was a broad-based space development business council, a Space Chamber of Commerce.

"If they can make it work maybe that would be great," Ladwig said. But he felt that the key issues "seem to be about the same as they were 30 years ago. We don't seem to have advanced the agenda a whole lot. … I guess if you could structure it right, then it would be fine. I just wonder what can you do to have this succeed where other activities like this have not had quite the success that people had hoped."

On the other hand, Davis said that the U.S. Chamber of Commerce "tends to be mainstream in what its issues are" and could bring more of the banking, accounting, and other business talents to bear on space issues. "I think that the kind of development business council should not be is all space cadets sitting here. It should be the travel agencies, the real estate agencies—get a broader brush into it. If it's well done, I think the time is right."

Tumlinson agreed that the time is right, citing the start of assembly of the *ISS* and the resulting need to be able to deal with issues such as having a Registered Deeds Office where a mortgage on privately financed capital can be recorded. This should be at the federal level, he argued, and can be written as "journeyman legislation" that a space business council could push through in one Congress. Further, Ali added, a standardized federal policy is needed because the various

SPACEHAB's plans for an Enterprise commercial module on the *ISS* could be the first step toward developing a space business park.

federal agencies have different goals. A council could set policy and give industry a way of understanding what the government is looking for and understanding the regulatory framework

"We have advocates for war," Tuck added, "we have advocates for science, we have advocates for all kinds of other things, but there's no advocate for people who like to go out and make money." With a Space Chamber of Commerce, Tumlinson continued, entrepreneurs like Bob Werb would have someone to call to get business moving.

An alternative is to recreate the National Space Council, a body which advised the president in the 1960's but has since been abolished. Corbett noted that "I have heard some pining for the National Space Council from a few people today, and yet I seem to recall that while it was in existence a lot of people were lobbing grenades at it. So absence does indeed make the heart grow fonder, perhaps?" Ladwig said that the Clinton transition team reexamined the issue but decided to place the functions within a larger National Science and Technology Council, which "has not paid much attention to space at all" other than in transportation issues. Davis said that because one-stop shopping is difficult, a single Federal clearing house is needed, but it will require more teeth and clout than the National Space Council had.

"The reason we need a National Space Council is because we do have all these agencies with their fingers in the pie," Corbett offered. "Maybe what we need is a real space agency" vested with all the space functions now scattered among various Federal agencies. "That is like saying there is one agency that controls the ocean," Ladwig countered. "And I don't think that is the case." He doubted that the problems in various agencies could be fixed by merging them into a single agency.

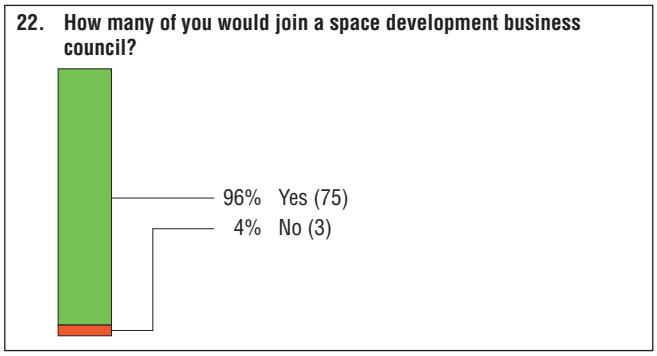
Another option is the public-private corporation. Yet when you get five people in a room to talk about privatization and commercialization, Ladwig noted, "you can come up with 10 different definitions of those." Even within NASA there is no clear definition, so he anticipates that the problem is the same at Defense, Commerce, and other departments. "I think how to deal with commercialization, privatization is something you

can't pin everything on NASA: it exists with other agencies as well. And certainly the Administration and Congress have not been especially consistent in that area either. … I would recommend that you come in and talk to Dan Tam [NASA, Assistant to the Administrator for Commercialization] about your space bank idea, and we are going to do everything we can to identify Murray."

"But I think we have to, as a nation, begin to make a psychological transition when it comes to space," Tumlinson added, "that space is a frontier. It is not a national lab, it is not a program anymore. It is a frontier. Within that concept of frontier, identify the appropriate roles of the private and public sectors and how they should interact."

Where explorers once tread with care, sightseers eventually travel with ease. For many people, the ultimate frontier in space commercialization will be space tourism.

Davis added that an overlooked issue is increased globalization as demonstrated even by the many flags that will be on the side of the *ISS* and the fact that few companies are entirely U.S.-owned anymore. And Ali noted that even as the day's discussions were under way, two operational LEO systems, Orbcomm and Iridium, were "being developed and need to become successful. Otherwise, the launch models, loan guarantees, and thousands of planned satellites that will go up in the next decade … will never materialize…."



Panel 3 audience electronic participation results (continued).

In closing the days activities, the program committee chairman, Mark Van Fleet, asked the private sector participants to indicate their interest in the formation of space council within the U.S. Chamber of Commerce. The results, shown above, has lead to the formation of the Space Enterprise Council.

APPENDIX—Forum Program Committee

Joseph Gilbert, Sr. Vice President, National Technology Transfer Center

Charles Lauer, Partner, Orbital Properties, Business Manager, Pioneer Rocketplane

John Mankins, Manager, Advanced Concept Studies, NASA Headquarters

Neville Marzwell, NASA Jet Propulsion Laboratory

James Muncy, Professional Staff, House Science Committee

David Smitherman (NASA Study Manager), Technical Manager, Advanced Projects Office, Flight Projects Directorate, NASA Marshall Space Flight Center

Mark Van Fleet (Committee Chairman), Manager, International Business Development, International Division, U.S. Chamber of Commerce

BIBLIOGRAPHY

General Public Space Travel and Tourism—Vol. 1, Executive Summary, NASA/NP—1998–03–11, Marshall Space Flight Center, AL, July 1998.

New Space Industries for the Next Millennium, NASA/CP—1998–209006, Marshall Space Flight Center, AL, December 1998.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 2000	Conference Publication

4. TITLE AND SUBTITLE
National Forum on
The Future Development of Space

5. FUNDING NUMBERS

6. AUTHORS
D. Dooling,* Compiler
D.V. Smitherman, Jr., Editor

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

8. PERFORMING ORGANIZATION REPORT NUMBER
M–989

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546–0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA/CP—2000–210428

11. SUPPLEMENTARY NOTES
Prepared for the Advanced Projects Office, Flight Projects Directorate
*D2 Associates, Huntsville, AL

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified-Unlimited
Subject Category 99
Standard Distribution

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The exploration of space has been a successful national priority for decades. We have landed on the Moon, built the Shuttle, and are building the *International Space Station*. But, we have only just begun to develop the real commercial potential of space. How large is this potential for the broader business community? What are the technology, policy, and business strategies required to harvest real business value from space? How can we as policymakers, investors, researchers, and business leaders ensure that the commercial development of space advances at a pace and breadth that brings most benefit to the national economy? To address these related questions, NASA and the U.S. Chamber of Commerce co-sponsored a 1-day National Form on the Future Development of Space, held March 16, 1999, in Washington, DC at the U.S. Chamber Headquarters. This report documents the key findings from this forum.

14. SUBJECT TERMS
space development, space tourism, space business, space policy

15. NUMBER OF PAGES
36

16. PRICE CODE
A03

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited